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Specification

1. Title of the Invention

Multilayer Circuit Board Manufacturing Method

2. Claims

A multilayer circuit board manufacturing method for forming a multilayer substrate of a hybrid integrated circuit with a condenser incorporated, the method comprising forming an interconnection conductor including an electrode for the condenser on an insulative printing substrate; providing a dielectric substance, covering said electrode; forming an insulating layer except on the dielectric substance and a conductor part for the connection to an upper circuit and making the insulating layer even with the dielectric substance; and forming an opposed electrode for the condenser.

3. Detailed Description of the Invention

The present invention relates to a method of manufacturing a multilayer circuit board including not only an interconnection conductor but also a resistor/a condenser formed in multi-layers, more specifically, a method for forming an electrode of the condenser.

To manufacture hybrid ICs or thick-film modules, the conductor interconnections are multilayered, and also the resistors and condensers are multilayered. FIG. 1 illustrates a conceptual sectional view of a multilayer circuit board manufactured by the conventional method. The multilayer circuit board is manufactured as follows. On an insulative printing substrate 1 of ceramics, a lower interconnection conductor 2, a lower resistor electrode 3, a lower condenser lower electrode 4 and an upper electrode terminal 5 are formed of a conductor paste. A lower resistor 6 is formed of a resistor

paste. A lower condenser layer 7 is formed of a dielectric paste, and an upper electrode 8 for the lower condenser is formed of a conductor paste. Thus, the lower circuit is formed.

Then, on the entire surface of the lower circuit except on the interconnection part to the upper circuit, an insulating paste, such as crystallized glass or others, is printed to thereby form an inter-layer insulating layer 9. A conductor paste is printed to thereby form an interconnection with the lower circuit via a through-hole 10 while forming an upper interconnection conductor 11 and an upper resistor electrode 12. A resistor paste is printed to form an upper resistor 13.

However, the thus-formed multilayer circuit board usually requires a film thickness of 50 - 40 μm so as to prevent the short-circuit of the thick-film condenser and to obtain high voltage resistance, and to this end, the insulating layer covering the condenser is convex and cannot have the surface planarized. Resultant problems are print blurs of the interconnection conductor overlaid over the convex insulating layer, scatter increase of the resistance value of the resistors, defective connections of mounted parts (not illustrated), restrictions of the circuit design for not forming the circuit convex, and other problems.

An object of the present invention is to provide a method for manufacturing a multilayer circuit board, which is free from the problems of the conventional art and planarizes the surface of the inter-layer insulating film formed on the condenser.

To achieve the above-described object, the present invention manufactures the multilayer circuit board illustrated in FIG. 2. That is, the present invention is characterized in that a lower resistor 6 and a condenser layer 7 are formed, then an inter-layer insulating layer 9' is formed in a thickness which is to be even with a height of the condenser layer except on the connection to an upper circuit and except on the connection

to the condenser layer 7 and the upper electrode 8 of the condenser, and then an upper electrode for the condenser is formed.

Example 1

A 96% Al_2O_3 sintered substrate was used, and the multilayer circuit board illustrated in FIG. 2 was formed as follows.

That is, on the Al_2O_3 substrate 1, an Ag-Pd type conductor paste was printed and sintered at 850°C for 10 minutes to form the lower interconnection conductor 2, the lower resistor electrode 5 and the lower electrodes 4 for the lower condenser.

Then, an RuO_2 -glass type resistor paste and a BaTiO_3 -glass type dielectric paste and sintered at 900°C for 10 minutes to form the lower resistor 6 and the lower condenser layer 7. Then, a crystallized glass paste was printed except on the condenser layer and the connections to the upper circuit and to the condenser upper electrode so that the inter-layer insulating layer 9' is even with a height of the condenser layer and then was dried at 150°C for 10 minutes. Then, an Ag-Pd type conductor paste was printed and sintered at 850°C for 10 minutes to form the lower condenser upper electrode 8, the intermediate interconnection conductor 14 and the conductor in the through-hole 10. Furthermore, said crystallized glass paste was printed except on the connections to the upper circuit and dried at 150°C for 10 minutes. Then, An Ag-Pd type conductor paste was printed and sintered at 850°C for 10 minutes to form the inter-layer insulating layer 9'', the upper interconnection conductor 11, the upper resistor electrode 12 and the conductor in the through-hole 10. Next, an RuO_2 -glass type resistor paste was printed and sintered at 850°C for 10 minutes to form the upper resistor 15.

At this time, the insulating layer with the condenser formed below was planarized, and the scatter ($3\sqrt{X} \times 100$) of the resistance value of the resistors on this insulating layer was $\pm 8\%$, which was a small scatter equal to the scatter of the resistors formed on the Al_2O_3 substrate. On the other hand,

the resistors formed by the conventional method had the shape broken, and the scatter of the resistance value was so large as $\pm 50\%$. In the conventional method, the conductors were thinned or broken at the bottom of the convex portions of the insulating layer. However, in the present invention, good and fine interconnections free from these defects were formed.

Furthermore, although not especially illustrated, the inter-layer insulating layer was planarized, which permitted mounted parts, such as ICs, transistors, diodes, etc., to be connected in good condition without breakage.

Example 2

As an insulative printing substrate, a green sheet was used, and the multilayer circuit board illustrated in FIG. 2 was formed as follows. The green sheet (non-sintered substrate) of a 10 mm-thickness was prepared by adding and slurry an organic polymer, a plasticizer and an organic solvent to a mixed powder of alumina of a average particle diameter of 2 - 3 μm or less, magnesia spinel, fine particles of calcium zirconate and fine particles of $\text{SiO}_2\text{-PbO-Al}_2\text{O}_3\text{-CaO-BaO}$ type glass and sheeted into the green sheet. This sheet was used as the printing substrate 1. On this printing substrate 1, an Ag-Pd type conductor paste was printed to form the lower interconnection conductor 2, the lower resistor electrode 3, and the dried film of the lower condenser lower electrode 4.

Then, an RuO_2 -glass type resistance paste and a BaTiO_2 -glass type dielectric paste were printed to form the lower resistor 6, the dried film of the lower condenser layer 7. Then, an insulating paste of the mixed powder of the green sheet is printed except on the condenser layer and the connections to the upper layer circuit and to the condenser upper electrode so that the inter-layer insulating layer 9' can be even with a height of the condenser layer. After dried, an Ag-Pd type paste was printed to form the lower condenser upper electrode 8, the intermediate interconnection conductor 14, and the conductor in the through-hole 10. Furthermore, said insulating

paste is printed except on the connection to the upper circuit and is air-dried, an Ag-Pd type conductor paste was printed, and an RuO₂-glass type paste was printed to form the upper interconnection conductor 11, the dried film of the upper resistor electrode 12, the conductor in the through-hole 10 and the dried film of the upper resistors. The dried films of the conductor, the resistor, the condenser and the insulating layer multi-layered on the green sheet were collectively thermally processed, retained at 850°C for 10 minutes in a thick belt furnace for air-sintering.

In the present example as well, the surface of the insulating layer with the condenser formed below was planarized, the scatter of the resistance value of the resistors can be small, good fine interconnections could be formed.

According to the present invention, the inter-layer insulating layer is free from convexity which is due to the thickness of the lower circuit especially the thick-film condenser and has the surface planarized, the upper circuit can be formed all over the surface of the insulating layer, the interconnections are free from thinning and breakage due to the print blur of the interconnection conductors, and the scatter of the resistance value of the resistors is substantially equal to that given by the usual thick-film technique. The connections of the mounted parts can be good.

4. Brief Description of the Drawings

FIG. 1 is a sectional view of one example of the multilayer circuit board prepared by the conventional method. FIG. 2 is a sectional view of one example of the present invention.

- 1: insulative printing substrate
- 2: lower interconnection conductor
- 3: lower resistor electrode
- 4: lower condenser lower electrode
- 5: lower condenser upper electrode terminal

- 6: lower resistor
- 7: lower condenser layer
- 8: lower condenser upper electrode
- 9: inter-layer insulating layer
- 10: through-hole
- 11: upper interconnection conductor
- 12: upper resistor electrode
- 13: upper resistor
- 14: intermediate interconnection conductor

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審査請求 未請求

(全 3 頁)

⑭ 多層回路板の製造方法

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明 細 書

1 発明の名称 多層回路板の製造方法

2 特許請求の範囲

コンデンサを内装する混成集積回路の多層
基板の製造方法において、絶縁性印刷基体上
にコンデンサ用電極を含む配線導体を形成し、
当該電極を覆って誘電体を配設し、誘電体な
らびに上層回路への接続用導体部を除いて絶
縁層を形成して誘電体との高さを等しくした
後、コンデンサ用対向電極を形成することを
特徴とする多層回路板の製造方法。

3 発明の詳細な説明

本発明は、配線導体のみならず抵抗体・コン
デンサを多層化した多層回路板の製造方法に係
り、特に、コンデンサの電極の形成方法に関す
る。

高密度に実装した厚膜ハイブリッドI²Cある
いは厚膜モジュールを製作するために、導体配
線の多層化のみならず、抵抗体やコンデンサの
多層化が行なわれ、第1図に従来の方法で製作

した多層回路板の模式断面を示す。この多層回
路板は次のようにして作成される。即ち、セラ
ミックスの絶縁性印刷用基体1上に導体ベース
トを用いて下層配線導体2、下層抵抗体用電極
3、そして下層コンデンサ用下部電極4および
上部電極用端子5を形成し、抵抗体ペーストを
用いて下層抵抗体6、誘電体ペーストを用いて
下層コンデンサ層7を形成し、導体ペーストを
用いて下層コンデンサ用上部電極8を形成して
下層回路を形成する。次いで、上層回路への接
続部を除いて下層回路の全面にわたって、結晶
化ガラス等の絶縁ペーストを印刷して層間絶縁
層9を形成し、導体ペーストを印刷してスルー
ホール10により下層回路との導通をとるととも
に、上層配線導体11、上層抵抗体用電極12を
形成し、抵抗ペーストを印刷して上層抵抗体13
を形成する。

しかし、このようにして形成する多層回路板
では、厚膜コンデンサの短絡をなくし、また、
高耐電圧を得るために通常50~40μmの膜厚を

要することから、コンデンサを覆う絶縁層部分が凸状となって平坦な絶縁層面が得られない。このため、凸状の絶縁層部分にかかる配線導体の印刷かすれ、抵抗体抵抗値のばらつきの増大、搭載部品（図示せず）の接続不良、あるいは、凸状部に回路を形成しないようにするための回路設計の制限がある等の問題があった。

本発明の目的は、前記従来技術の欠点を無くし、コンデンサ上に形成する層間絶縁層の表面を平坦化するための多層回路板の製造方法を提供することにある。

本発明は、上記目的を達成するため、第2図に示すような多層回路板とすることにある。即ち、本発明の特徴は、下層の抵抗体6およびコンデンサ層7を形成した後、上層回路への接続部以外にコンデンサ層7ならびにコンデンサ用上部電極8への接続部を除いて層間絶縁層9'をコンデンサ層の高さと同じとなるような厚さに形成し、その後コンデンサ用上部電極を形成することにある。

ストを印刷し、850℃で10分間焼成して層間絶縁層9'、上層配線導体11、上層抵抗体用電極12およびスルーホール10内への導体の形成を行なった。次いで、 KuO_2 -ガラス系抵抗ペーストを印刷し、850℃で10分間焼成して上層抵抗体13を形成した。

この時、下層にコンデンサが形成された絶縁層は平坦化され、この絶縁層上の抵抗体の抵抗値のばらつき（ $3\sigma/\bar{x} \times 100$ ）は±8%であり、 Al_2O_3 基板上に形成した抵抗体のばらつきと同等の小さなばらつきであった。一方、従来の方法で形成した抵抗体では、抵抗体の形状が崩れ、抵抗値のばらつきも±30%と極めて大きいものであった。また、従来方法では、絶縁層の凸状部の裾部に導体の細りや断線がみられたが、本発明ではこれらの欠陥のない良好な微細な配線が形成できた。

さらに、特に図示しないが、層間絶縁層が平坦化されるため、IC、トランジスタ・ダイオード等の搭載部品の接続も断線なく良好にでき

実施例1

96% Al_2O_3 焼結基板を用い、第2図に示す多層回路板を次に示すようにして作成した。即ち、 Al_2O_3 基板1上にAg-Pd系導体ペーストを印刷し、850℃で10分間焼成して下層配線導体2、下層抵抗体用電極3、下層コンデンサ用下部電極4を形成した。次に KuO_2 -ガラス系抵抗ペースト、および $BaTiO_3$ -ガラス系誘電体ペーストを印刷し、900℃で10分間焼成して下層抵抗体6、下層コンデンサ層7を形成した。その後、コンデンサ層、上層回路およびコンデンサ用上部電極との接続部を除いて層間絶縁層9'がコンデンサ層の高さと同じとなるよう結晶化ガラスペーストを印刷し、150℃で10分間乾燥後、Ag-Pd系導体ペーストを印刷し、850℃で10分間焼成して下層コンデンサ用上部電極8、中間層配線導体14およびスルーホール10内への導体の形成を行なった。さらに、上層回路との接続部を除いて前記結晶化ガラスペーストを印刷し、150℃で10分間乾燥後、Ag-Pd系導体ペー

た。

実施例2

絶縁性印刷基体としてグリーンシートを用い、第2図に示す多層回路板を次に示すようにして作成した。平均粒径が2~3 μm 以下のアルミナ、マグネシアスピネル、ジルコン酸カルシウムの微粉末と、 $SiO_2-PbO-Al_2O_3-CaO-BaO$ 系ガラス微粉末からなる混合粉末に有機高分子、可塑剤および有機溶剤を加えて泥しよう化し、シート化して10mm厚のグリーンシート（未焼成板）を形成してこれを印刷基体1とした。この上に、Ag-Pd系導体ペーストを印刷し、下層配線導体2、下層抵抗体用電極3、下層コンデンサ用下部電極4の乾燥膜を形成した。次に KuO_2 -ガラス系抵抗ペーストおよび $BaTiO_3$ -ガラス系誘電体ペーストを印刷し、下層抵抗体6、下層コンデンサ層7の乾燥膜を形成した。その後コンデンサ層、上層回路およびコンデンサ用上部電極との接続部を除いて、乾燥後の層間絶縁層9'がコンデンサ層の高さと同じとなるようグリーン

